Examining the Exposure to Extreme Weather Events and Risk of Campylobacteriosis and Salmonellosis in Maryland, USA

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Background

- Annually across the United States:
  - *Campylobacter* causes ~1 million cases of gastroenteritis
    - Functional gastrointestinal disorders
    - Inflammatory bowel disease
    - Celiac disease
    - Reactive arthritis
    - Guillain-Barre syndrome
  - *Salmonella* causes ~1.2 million cases of acute gastroenteritis, including 23,000 hospitalizations and 450 deaths
    - Enteric fever
    - Food poisoning
- Infection routes via tainted water or food

Relationship to Weather

- Increased risk of campylobacteriosis associated with:
  - Seasonality
  - Daily maximum temperatures
  - Mean weekly temperature
  - Precipitation

- Previous time-series studies have identified associations between average temperature and the number of reported cases of Salmonella infection

The Direction of Extreme Weather Events

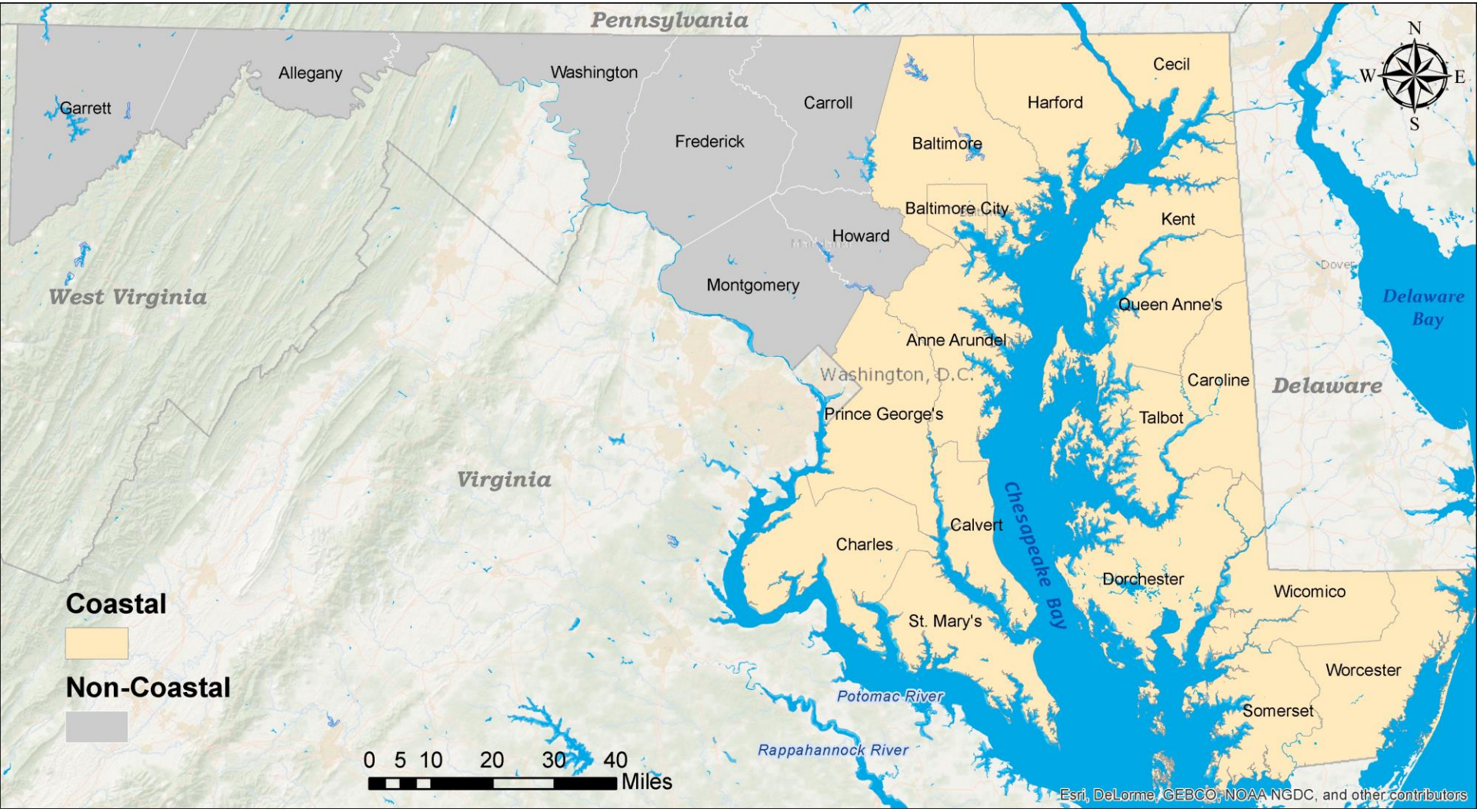
Intergovernmental Panel on Climate Change (IPCC) has suggested that the ***intensity, frequency, and length*** of extreme weather events will continue to increase as a result of a changing climate (Field et al. 2012)

Our Focus

- Limited data exist on how specific enteric illnesses (e.g., campylobacteriosis and salmonellosis) may be influenced by the frequency of extreme weather events

- Unclear if risk may disproportionately impact coastal communities already vulnerable due to flooding and sea-level rise

Study Area: Maryland, USA



Case Data

- Maryland Foodborne Diseases Active Surveillance Network (FoodNet)
  - Jan to Dec from 2002 to 2012
  - Date of confirmed case, species, age, race, and gender

- *Campylobacter* (n=4,804)
- *Salmonella* (n=9,529)

- County level variables (2010 Population and Housing Summary Census)
  - Age
  - Gender
  - Race
  - Socioeconomic data (American Community Survey 2006-2010)

Focusing On The Exposure Metric

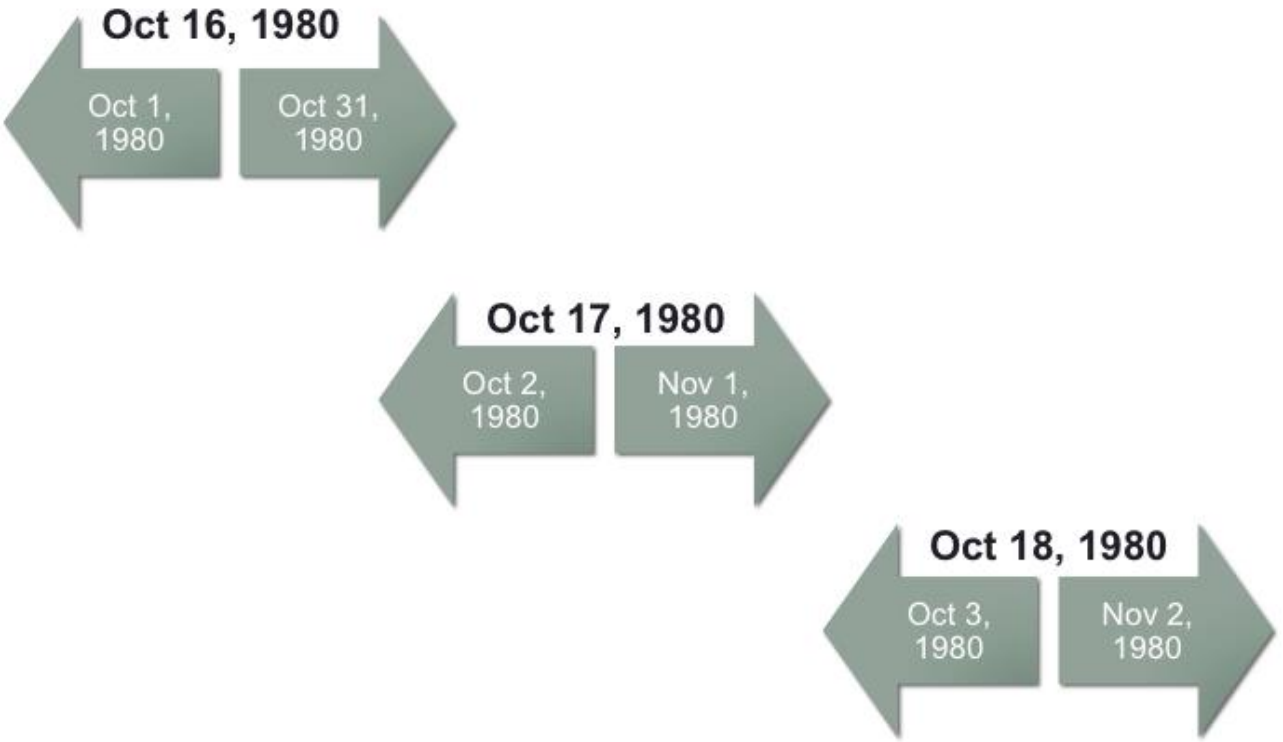
Background

- Differing methodologies for defining temperature
  - Linear
  - Non-linear (splines)
  - Threshold
  - Season

- Our exposure metric: **Extreme Heat** and **Precipitation Events**
  - Built using location and calendar day specific climatology

Defining Extreme Heat and Precipitation Events

- Baseline data from 1960-1989
  - Weather stations from National Climate Data Center
  - Averaged by county and day
  - Baseline values for each day based on 31-day window



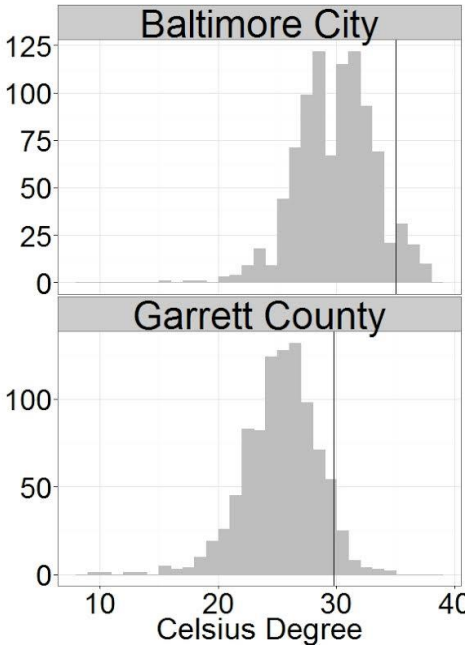
Defining Extreme Heat and Precipitation Events

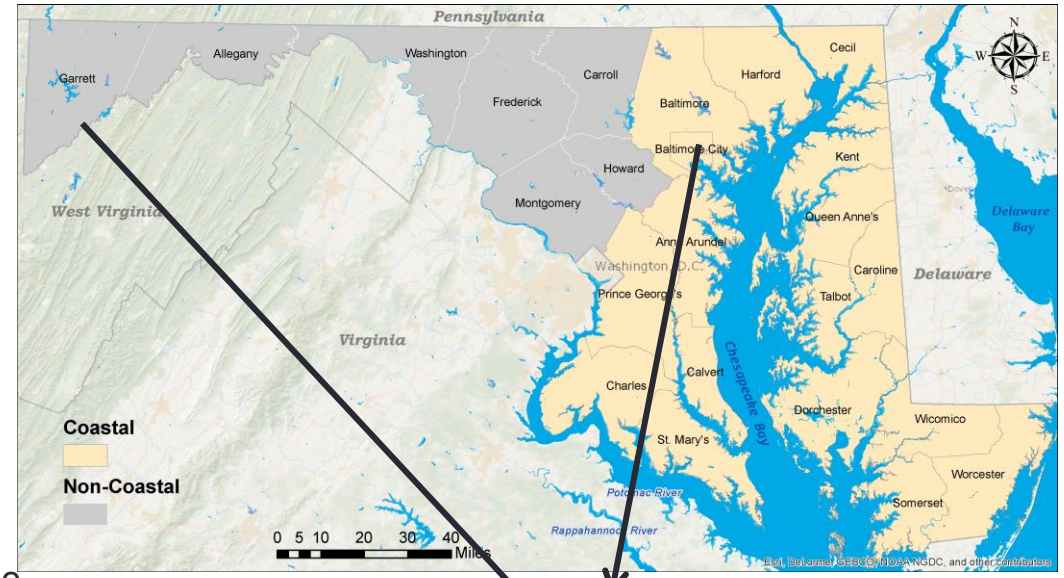
- From baseline data created distribution of maximum daily temperature and precipitation values for each county and day

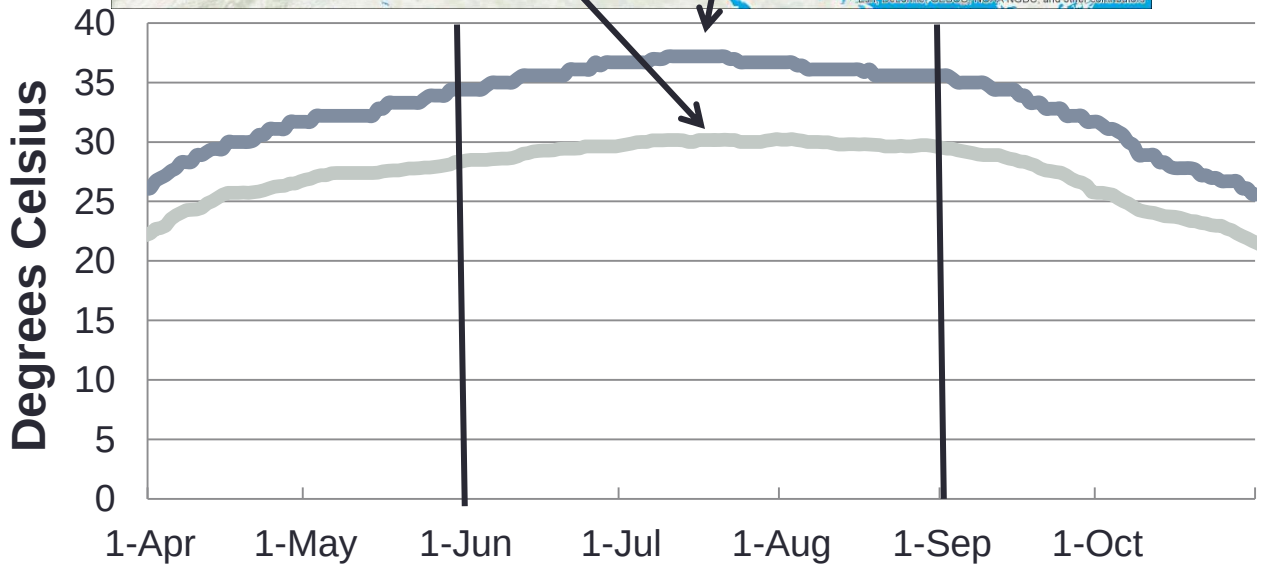
- Utilizing the distribution of this data, thresholds were identified for each county and calendar day
  - 95^{th} percentile (ETT_{95}) = Extreme Heat
  - 90^{th} percentile (EPT_{90}) = Extreme Precipitation

Extreme Heat Threshold

Example: Extreme Heat (ETT_{95}) values on July 1st (Range: 30-36 °C)







Defining Extreme Heat and Precipitation Events

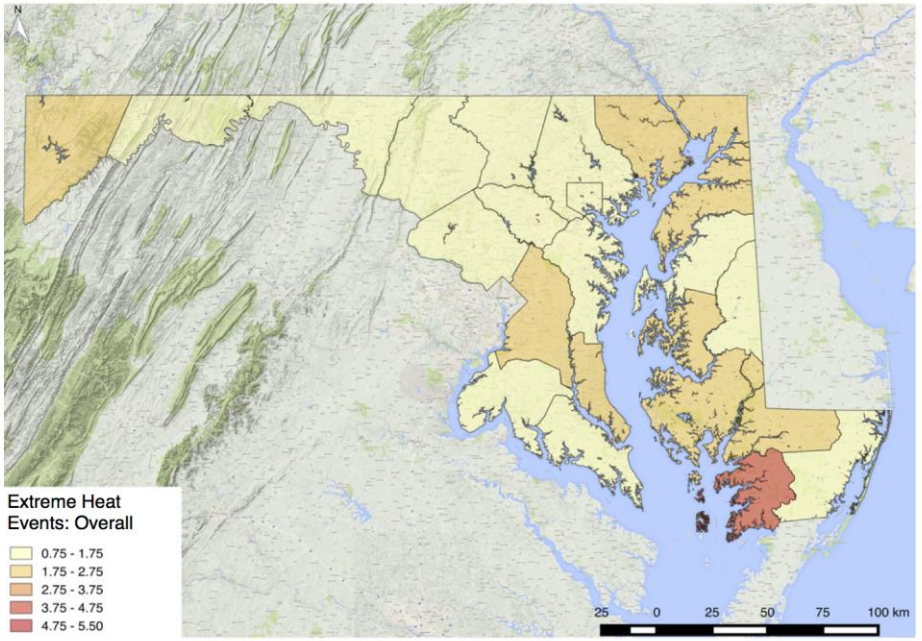
- Extreme Heat Events: dichotomous variable
  - 1: if Tmax for a given day > Extreme Heat (ETT_{95})
  - 0: Otherwise
  - Same for Extreme Precipitation Events (EPT_{90})

- By county and day we can ask ourselves?
  - Is Jan 1 2002 greater or less than Jan 1 threshold?
  - Is Jan 1 2003 greater or less than Jan 1 threshold?
  - Is Jan 1 2004 greater or less than Jan 1 threshold?
  - Etc…

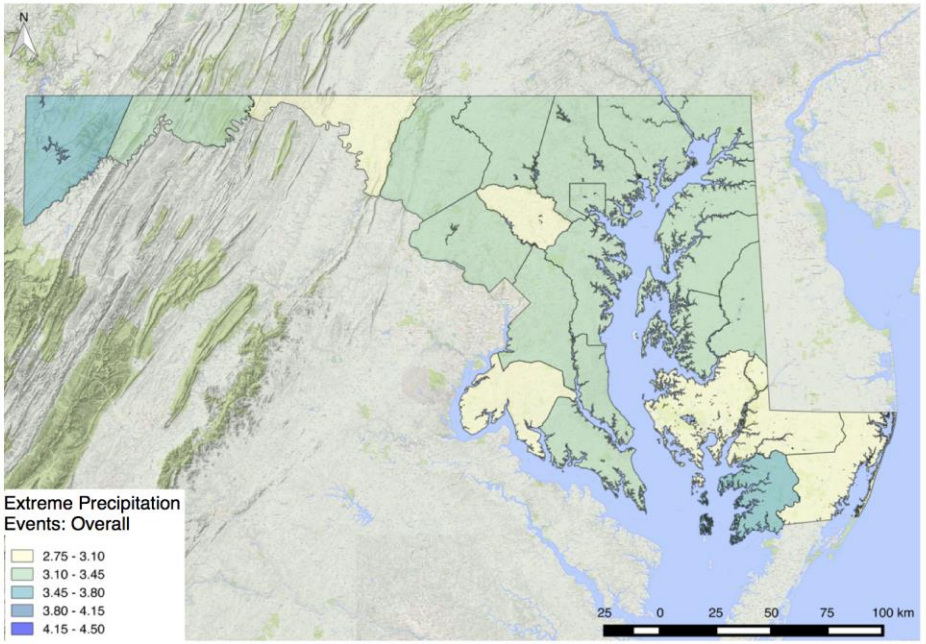
Monthly Average of Extreme Events by County

2000-2012 Overall

Extreme Heat Events



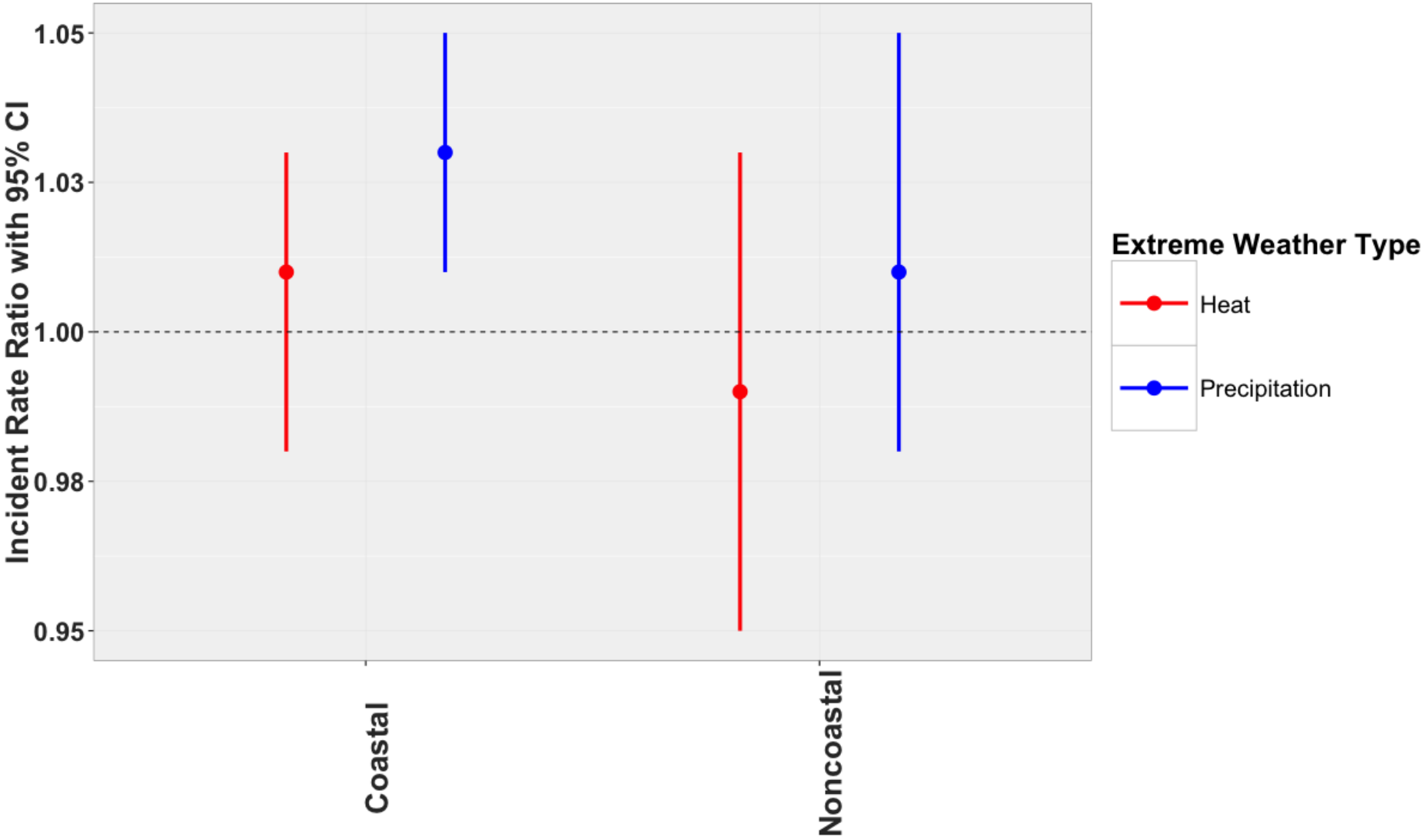
Extreme Precipitation Events



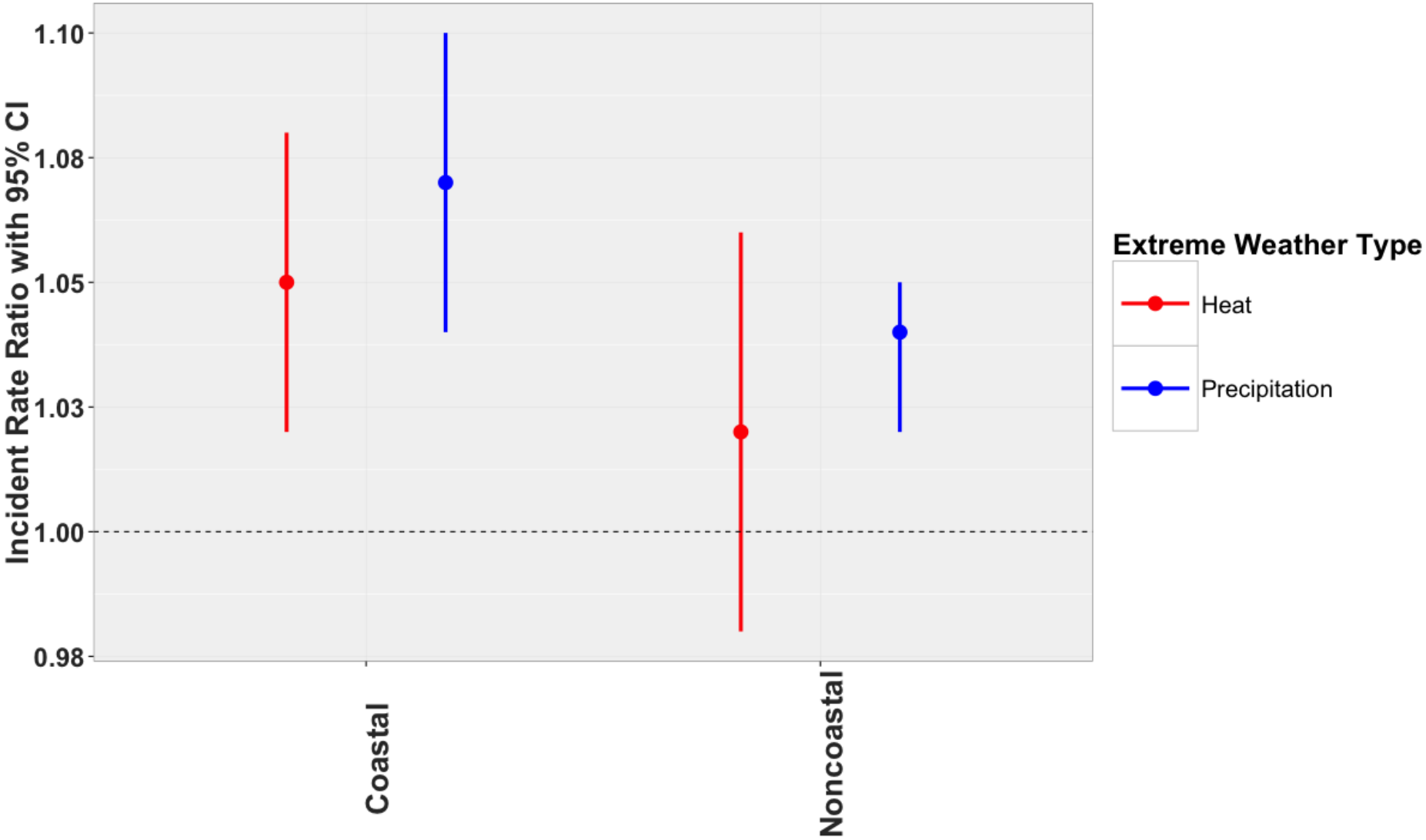
Statistical Analysis

- Case and extreme weather events aggregated by month and county
- Negative Binomial Generalized Estimating Equations
- Models:
  - Overall - adjusted for age, gender, race, poverty %
  - Stratified models by:
    - Coastal vs. Noncoastal
- Sensitivity analyses
  - Different threshold to define extreme events (90^{th}, 95^{th}, 99^{th} percentiles)

Risk of Campylobacteriosis



Risk of Salmonellosis



Discussion

- Due to its low-lying flat plain, the Eastern Shore is particularly vulnerable to flooding

- Extreme precipitation events may exacerbate potential water-related transmission pathways
  - Considerable percentage of the coastal population utilizes well water, which may become contaminated
  - Close proximity to water bodies in the coastal areas may mean increased frequency of exposure to contaminated water during recreation

Strengths and Limitations

Strengths

- Relative temperature and precipitation threshold used
  - Reflected the variability in extreme heat/precipitation to each calendar day and county
- Health outcome data encapsulated a lengthy period (2002 to 2012) that encompassed substantial variability for the exposure and health outcome measures

Limitations

- No examination of intensity or duration of extreme weather
- No information on occupational status or specific outbreaks
- Small study area (24 counties in Maryland), with potential for coastal areas to be different than other U.S. coastal regions
  - Presence of concentrated animal feeding operations
  - Substantial portion of the population that uses well water

Conclusion

- Study provides empirical evidence for the association between frequency of extreme **heat** and **precipitation** events and risk of campylobacteriosis/salmonellosis

- Adaptation strategies need to account for the coastal vs. noncoastal differential burden, particularly in light of ever increasing coastal populations

- Future studies with data from multiple states are needed to further evaluate coastal/noncoastal area differences

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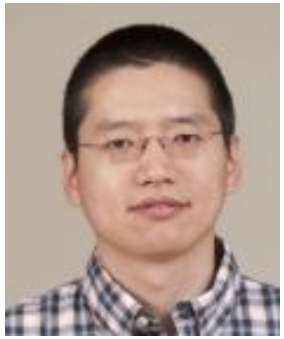

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Thank you!

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Maryland

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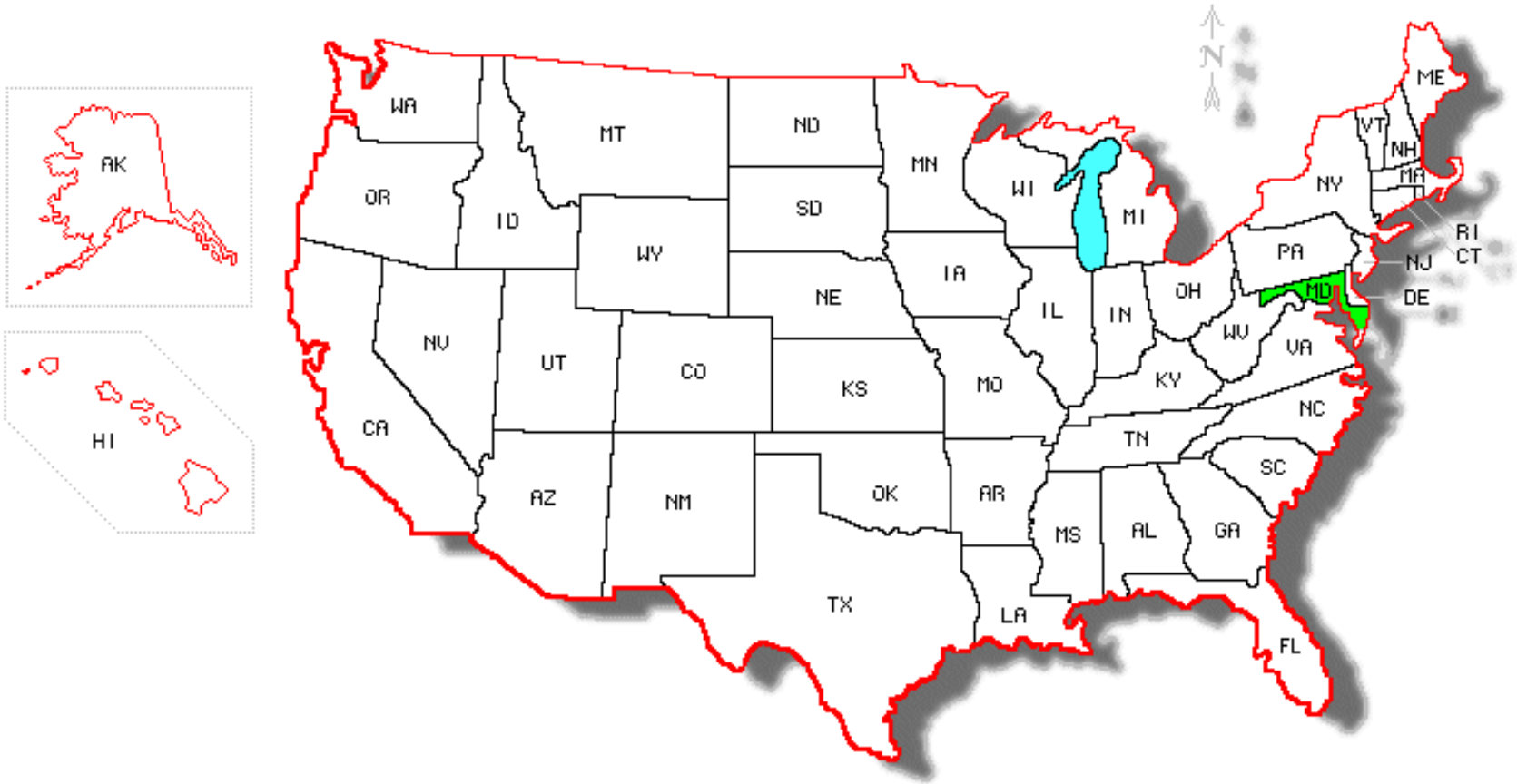
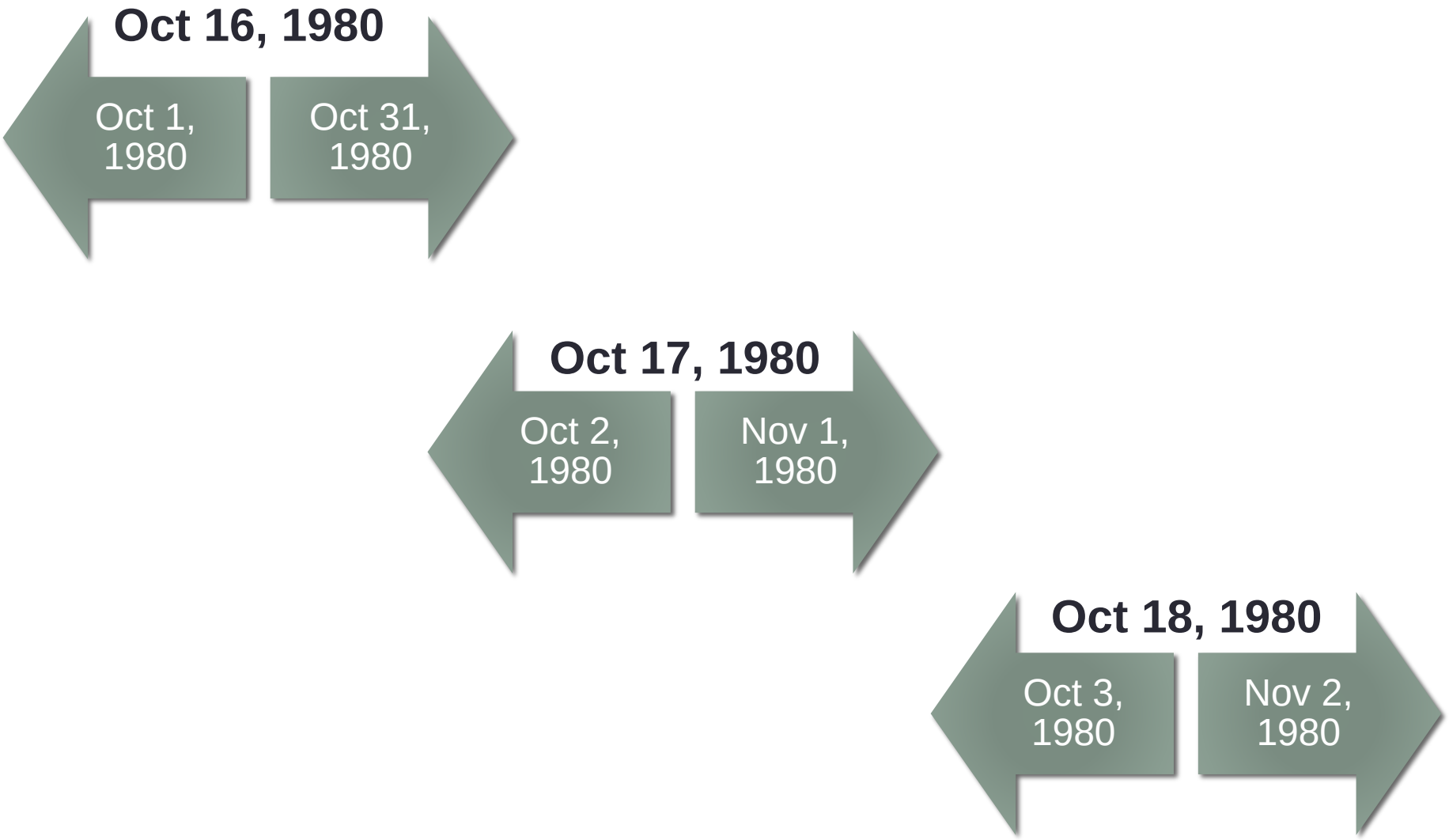



Oct 16, 1980
Oct 1, 1980
Oct 31, 1980
Oct 17, 1980
Oct 2, 1980
Nov 1, 1980
Oct 18, 1980
Oct 3, 1980
Nov 2, 1980

Demographic Characteristics: *Campylobacter*

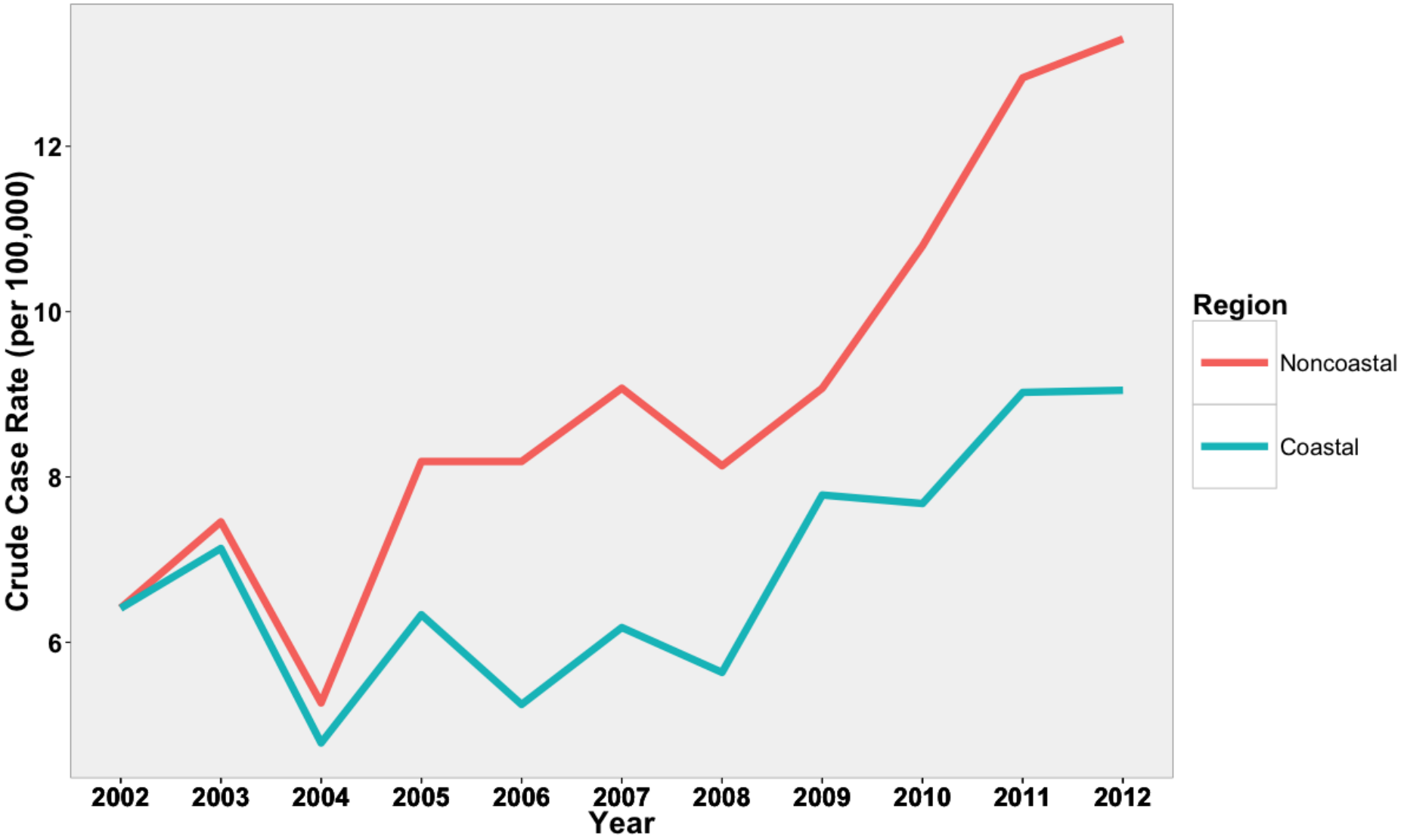
Characteristic	Region		
	Coastal No. (%)	**Noncoastal** No. (%)	**All** No. (%)
Total	2,911(61%)	1,893 (39%)	4,804 (100%)
Gender			
Male	1,555 (53)	1,025 (54)	2,580 (54)
Female	1,352 (47)	861 (46)	2,213 (46)
Unknown	4 (0.1)	7 (0.3)	11 (0.2)
Age (years) [median (interquartile range)][Ŧ]	39 (21-54)	36 (18-53)	38 (20-53)
Age Group			
<5	308 (11)	205 (11)	513 (11)
5-17	309 (11)	260 (14)	569 (12)
18-64	1,953 (67)	1,231 (65)	3,184 (66)
≥65	334 (12)	188 (10)	522 (11)
Unknown	7 (0.2)	9 (0.5)	16 (0.3)
Race/Ethnicity			
Non-Hispanic White	1,719 (59)	707 (37)	2,426 (51)
Non-Hispanic Black	371 (13)	36 (2)	407 (9)
Hispanic	147 (5)	76 (4)	223 (5)
Other	86 (3)	57 (3)	143 (3)
Unknown	588 (20)	1017 (54)	1605 (33)
Season[a]			
Winter	454 (16)	318 (17)	772 (16)
Spring	569 (20)	382 (20)	951 (20)
Summer	1,168 (40)	800 (42)	1,968 (41)
Autumn	720 (25)	393 (21)	1,113 (23)

Demographic Characteristics: *Salmonella*

Table 1.
Characteristics of reported Salmonellosis cases: Maryland, 2002 to 2012.

Characteristic		# Cases	% of Cases	Composition of MD population (%)
Age				
	< 5	2380	25	6.3
	5 to 17	1661	17.4	17
	18 to 64	4462	46.8	64.3
	65 and over	979	10.3	12.4
	Unreported	47	0.5	NA
Gender				
	Female	5023	52.7	50.9
	Male	4475	47	49.1
	Unreported	31	0.3	NA
Race				
	Non-Hispanic White	3755	39.4	54.7
	Non-Hispanic Blacks	2509	26.3	29
	Hispanic	515	5.4	8.2
	Other races	293	3.1	8.2
	Unreported	2457	25.8	NA

Campylobacteriosis Crude Incidence Rate



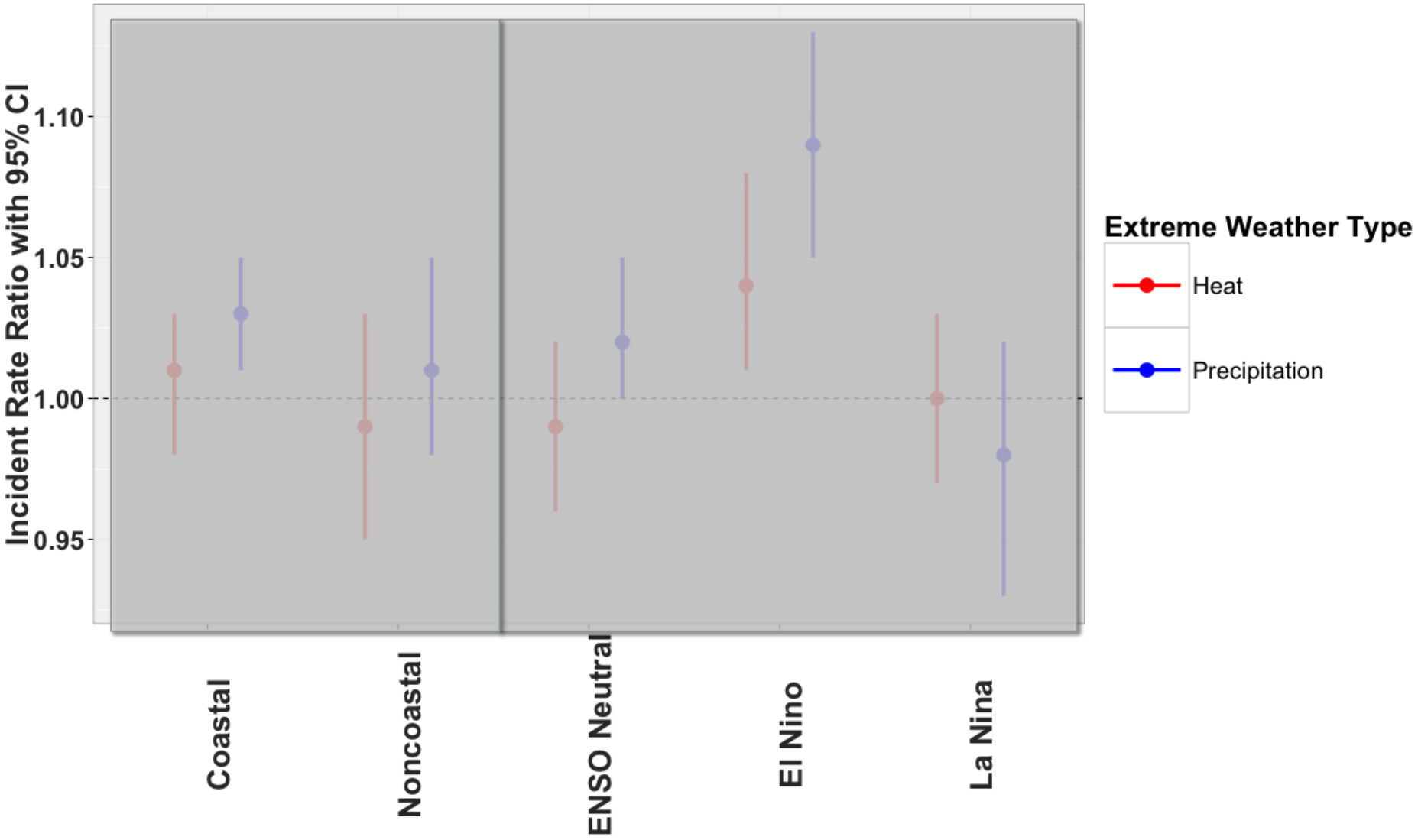
Results

- We observed that a one day increase in exposure to extreme precipitation event was associated with a 3% increase in the risk of campylobacteriosis in coastal areas of Maryland but such an association was not observed in noncoastal areas

Results summary salmonella

- We observed a 4.1% increase in salmonellosis risk associated with a 1 unit increase in extreme tempera- ture events (incidence rate ratio (IRR):1.041; 95% confidence interval (CI):1.013–1.069). This increase in risk was more pronounced in coastal versus non-coastal areas (5.1% vs 1.5%). Likewise, we observed a 5.6% increase in salmonellosis risk (IRR:1.056; CI:1.035–1.078) associated with a 1 unit increase in extreme precipitation events, with the impact disproportionately felt in coastal areas (7.1% vs 3.6%).

Risk of campylobacteriosis due to extreme heat/precipitation events



Risk of salmonellosis due to extreme heat/precipitation events